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Influence of climatic parameters on the algae yield in man-made ponds

Saiful Iskandar Khalit[1]*, Azman Azid[1], Nurul Safinaz, Mohd Kamal[2], Mohd Ghazali Hassan[3], Marryanna Lion[3], Ibharim Hasim[3], Mat Yusof Mat Rani[1] and Hafizi Mohd Jaffar[3]

[1]Faculty of Bioresources and Food Industry, Universiti Sultan Zainal Abidin (UniSZA), Besut Campus, 22200 Besut Terengganu. **Malaysia**

[2]University Laboratory Management Unit, Universiti Teknologi Malaysia Kuala Lumpur, Jalan Sultan Yahya Petra, 54100 Kuala Lumpur. **Malaysia**

[3]Forest Research Institute Malaysia (FRIM) 52109 Kepong Selangor **Malaysia**

***Correspondence:** saifuliskandar@unisza.edu.my **Revised: 0**6 Aug. 2019, **Accepted:** 10 Oct. 2019, **e-Published:** 06 Nov. 2019
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Climate has an influence to the production of algae in the artificial and natural ponds as well. Most of the climatic parameters that indicate the algae yield are temper ature and rainfall. Algae have been used in many monitoring programs in determination of water quality changes in ponds, rivers and lakes. Ponds at different locations have different environmental condition that they experienced will tend to have different algae contents. Sampling was conducted daily at three different times at two ponds in Forest Research Institute Malaysia (FRIM) known as Pond 1 and Pond 2. Algae data was measured using a handheld chlorophyll fluorometer, AquaPen-P AP-P 100 (Photon Systems Instruments). Besides, total rainfall was measured manually daily at once in the morning by using a measuring cylinder while temperature was obtained from the Automatic Weather Station. In other hands, this study was carried out to compare and determine the relationship of the total rainfall and temperature factors with chlorophyll contents in two existing man-made ponds in FRIM. Both rainfall and temperature has negative and positive relationship with algae content, respectively. Small pond with shady area has low algae contents as compared to pond with large and more exposure to light. Low rainfall event and more light penetration had led to more algal production. Moreover, the surrounding environment also being affected in fluctuation of chlorophyll contents in the ponds. Since, eutrophication phenomenon undertaken more shortcomings rather than benefits, hence, further study on monitoring the physical and chemical water quality parameters especially in nutrient concentration received by ponds which being the catalyst to eutrophication is highly recommended.

Keywords: ponds; total rainfall; chlorophyll; temperature; algae

INTRODUCTION

Water bodies of Forest Research Institute Malaysia (FRIM) are important components of ecosystem integrity of FRIM. FRIM formerly known as FRI was an ex-mining and agriculture areas. Information on the changes of water body in forested area is very important especially with respect to diversity of flora and fauna in FRIM, water quality for recreational and drinking purposes and also tree growth. Changes in water quality are closely associated with land use patterns.

FRIM has micro-climate characteristics of different temperature from an open area. This is because the forest ecosystem has its own characteristics with a space under the canopy which closes and limits the sunlight to reach the forest floor. Thus, the enclosed space between the forest floor and canopy creates a temperature lower than outside the forest area.

All plants and algae containing green pigment called chlorophyll a which is necessary for photosynthesis. Algae have been used in many monitoring programs to determine the changes in water quality of lakes, ponds and rivers (Addy and Green, 1996; Araoye, 2002). The measurement of chlorophyll a content in a sample of pond water is best enough for algal biomass content even not being a direct correlation (Sarehati, 2012).

Algae exist in two main forms; micro and macro algae. Not all algae tend to be in green color. It depends on which pigments are dominant in their cells. Like other forms of plants, algae known as autotrophs which use chloroplast to trap sunlight for photosynthesis activities (Addy and Green, 1996; Surendar et al., 2013).

Photosynthesis is the process of converting water and carbon dioxide into sugar (food) in the presence of sunlight and also generating oxygen as a by-product (Addy and Green, 1996). Algae plays vital role in all aquatic ecosystems as food and energy base of lake food chains. However, any excess of algal growth may lead to algal bloom formation or known as eutrophication phenomenon (Addy and Green, 1996).

Extremely high algal biomass usually decrease aesthetic beauty, reducing water clarity and create taste and odor problems other than increases the decomposition process of dead algae which consume high amount of dissolved oxygen and subsequently caused fish kills in some lakes (Addy and Green, 1996; Pinto et al., 2001; Davies et al., 2008).

According to Diana et al., (1991), rainfall is included as a factor that influencing primary production of ponds. The daily solar radiation level also affected the photosynthesis activities. Since different pond with different location and surrounding may experience different stress including in terms of environmental factors. Assessments of chlorophyll a contents at different ponds may result in different value. This study is important to relate the effect of chlorophyll content based on their climatic parameters such as total rainfall and temperature. In addition, this study also comparing the chlorophyll content between two ponds in FRIM.

MATERIALS AND METHODS

FRIM (Forest Research Institute Malaysia) is located in Kepong, Selangor about 16 km northwest of Kuala Lumpur. This institute has 544 ha site which adjacent to the Bukit Lagong Forest Reserve. In 10 February 2009, FRIM was gazetted as a 'Natural Heritage Site' under the National Heritage Act 2005. Later, in 10 May 2012, it is officially categorized as the National Heritage. Two ponds in FRIM (Pond 1 and Pond 2) were selected as the study area as shown in Figure 1. Pond 1 is a small man-made pond located next to D6 building which receives water sources that pumped out from groundwater while Pond 2 is located in Kepong Botanical Garden (KBG).

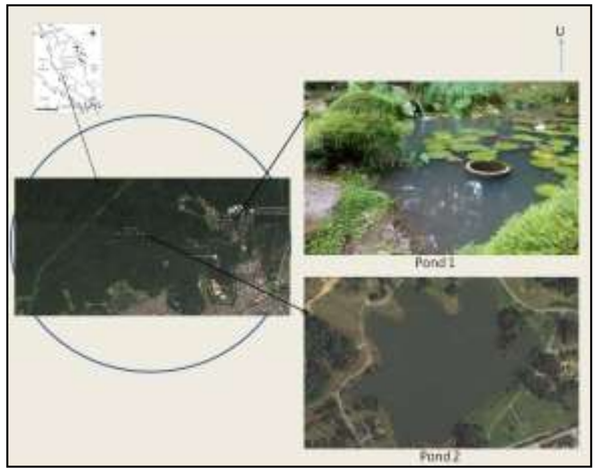

Figure 1; The study area in FRIM ponds.

The Global Positioning System (GPS) coordinates for both ponds were determined using GPS handheld which enable to locate data observation as well as sampling point respectively. Table 1 showed that the GPS point of sampling station at pond 1 and 2. All coordinates were stored in the Universal Transverse Mercator (UTM) system coordinates format as follows:

Table 1; Coordinates of sampling points

Pond	Coordinates
1	VK 404394, WMR 358118
2	St1: VK402496, WMR356987 St2: VK402636, WMR357031 St3: VK402748, WMR356980

Sampling was conducted daily during three different period at two ponds in FRIM (Pond 1 and Pond 2). Pond 1 is a small man-made pond located next to D6 building which receives water sources from pumped-out groundwater. This pond contains a few number of lotus plant. Pond 2 is located in Kepong Botanical Garden (KBG) which is a large man-made pond that receives water sources from nearest small ponds and catchment area. This pond has lack of aquatic plant.

Chlorophyll-a was measured as maximum quantum yield. Chlorophyll fluorescence is an effective approach to determine the efficiency of photosystem II and can be expressed as the ratio of the rate of the photochemical activity and the total rate of absorbed energy dissipation (Fv/Fm). The decrease in Fv/Fm showed that the photosynthetic efficiency of the algae was affected. The increase in Fv/Fm indicates the increase in chlorophyll-a contents and growth. The measurement of Fv/Fm determines the photosynthetic status of algae in ponds either has been exposed to stress or not (Hazlina and Luqman, 2013).

The maximum quantum yield of chlorophyll in each pond was measured by using a handheld chlorophyll fluorometer (Figure 2) known as AquaPen-P AP-P 100 (Photon Systems Instruments).

Figure 2. The AquaPen-P AP-P 100

At the start of the measurement, a short, red, actinic pulse (~3000 µmol $m^{-2}s^{-1}$ at 655 nm) was prompted for 5s to ensure a stabilized fluorescence emission during the following Fm measurement. Then, Fo was measured with a pulsed, blue measuring light (~900 µmol $m^{-2}s^{-1}$ at 455 nm) and Fm was determined with a saturating white light pulse (~3000 µmol $m^{-2}s^{-1}$). Fo is the fluorescence intensity at 50 µs while Fm is the maximal fluorescence intensity. The maximum quantum yield, Fv/Fm was calculated as (Fm–Fo)/ Fm (Hazlina and Luqman, 2013).

The total rainfall was measured manually in unit of mm; daily at once in the morning by using a measuring cylinder (Figure 3).

Figure 3. Rainfall measuring instrument

RESULTS

Daily monitoring of algae yield was conducted in an inter-seasonal period. The average monthly data of chlrophyll-a and temperature were compared with rainfall data that available in WeatherLink 6.0.3 software as well. The data on temperature also was extracted from the same software. All of the results were analyzed and constructed by using Microsoft Excel.

From the Figure 4 (a), (b) and (c), it can be observed that the chlorophyll-a yield in the afternoon and evening is higher than in the morning during monitoring period from July to September. It is due to rising of sun during afternoon and early-evening (from 12 noon to 3 pm). It had boosted the surrounding temperature and light intensity as well effected of algal growth respectively.

Based on the result obtained as from Figure 4(a), it showed that chlorophyll-a yield in Pond 1 was lower than Pond 2 during morning period in the range of approximately from 0.5 to 0.6 µg/L over the month. The chlorophyll-a yield in July at Pond 2 was indicated 0.7 µg/L which was the highest compared to August and September.

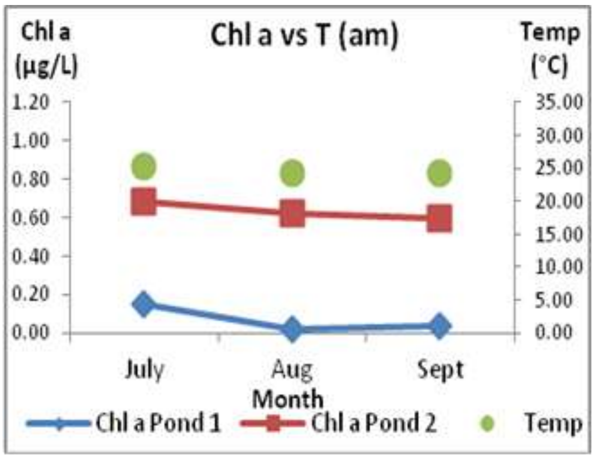

Figure 4(a). Chlorophyll-a content versus temperature (am) in the morning.

Observation result from Figure 4(b) showed that chlorophyll-a yield in Pond 1 was still lower than Pond 2 during noon period in the range of nearly from 0.55 to 0.95 µg/L over the month.

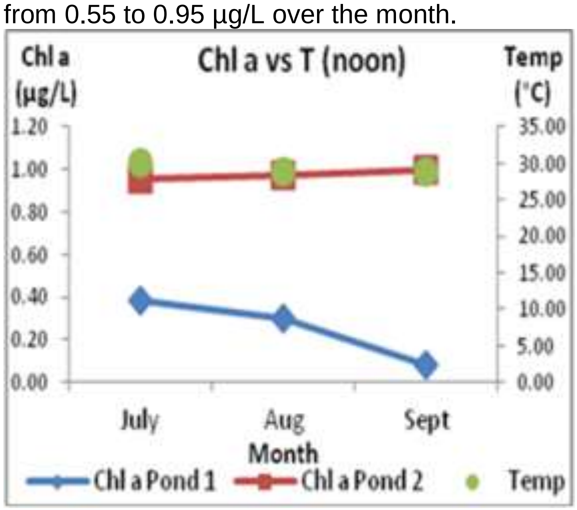

Figure 4(b). Chlorophyll-a content versus temperature (noon) in the afternoon.

The chlorophyll-a yield in September at Pond 2 was indicated 1.05 µg/L which was the highest compared to July and August.

From Figure 4(c), it showed that chlorophyll-a yield in Pond 1 was still lower than Pond 2 during noon period in the range of nearly from 0.40 to 0.80 µg/L over the month. The chlorophyll-a yield in September at Pond 2 was indicated 1.00 µg/L which was the highest compared to July and August.

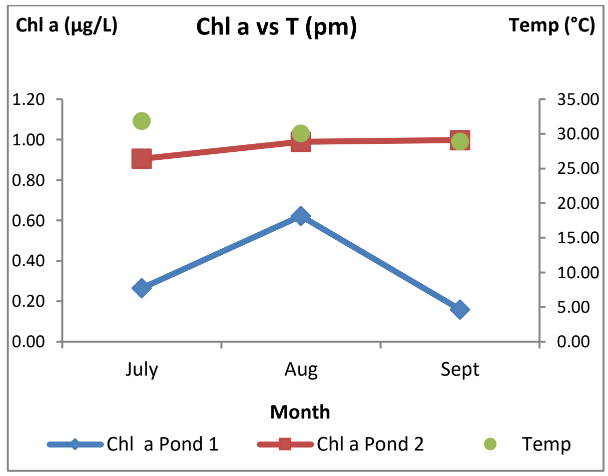

Figure 4(c). Chlorophyll-a content versus temperature (pm) in the evening.

DISCUSSIONS

The chlorophyll-a measurement is considered to be a useful tool to monitor photosynthetic activity. It is commonly used to evaluate the effect of different kinds of stresses such as climatic changes, rainfall pattern and impact from water quality.

The impact of climatic parameter such as temperature led the higher chlorophyll-a yield in the afternoon and evening compared to in the morning during monitoring from July to September. The elevated afternoon and early-evening surrounding temperature and light intensity had boosted the algal growth. (Asma Liyana Shaari et al., 2011; Abolude et al., 2012; Neto & Otrensky, 2013; Tamburic et al., 2014)

High intensity of raining was recorded in July had caused the chlorophyll-a yield indicated lower as compared to chlorophyll yield in August and September. This was due to rain that had washed away the soil surfaces and caused the settling effects of suspended materials on the surface of water. These materials inhibit light penetration into the pond and subsequently resulted in the reduction the photosynthesis activities (Asma Liyana Shaari et al., 2011; Abolude et al., 2012). The increase of water level after raining event also had caused to the dilution of the nutrient concentration that essential for algae growth (Abolude et al., 2012; Ahmad et al., 2013). Nutrient such as ammonia and nitrate are used for algae to grow. Moreover, low light available that occurs during raining season also had reduced the algae production (Prabhakar et al., 2009) as the sky was enclosed by cloud.

As compared between two ponds, Pond 2 recorded higher chlorophyll-a content than Pond 1. Rainfall had washed away the fertilizers with rich nutrients input that has been used for plant into the pond. The pond receives high fertilizer inputs had higher nutrients concentrations in water, and higher primary production (Diana et al., 1991; Addy and Green, 1996). Inorganic fertilizer is favorable to induce the algal growth due to its higher nutrient contents such as Nitrogen, Phosphorus and Potassium.

Besides, high light exposure experienced by Pond 2 to direct sunlight as it was surrounded by most small trees encouraged algae production. In addition, high canopy that enclosing Pond 1 had reduced the light penetration received by the algae that essential to undergo photosynthesis activity.

CONCLUSION

During inter monsoon period, the rainfall and temperature are that most influenced climatic parameters that significant to the growth of algae yield. Low rainfall event and more light penetration had led to more algal production. Moreover, the surrounding environment also being the aspects in determination of chlorophyll contents in ponds.

Since, eutrophication phenomenon gives more shortcomings rather than benefits, hence, further study on monitoring the physical and chemical water quality parameters especially in nutrient concentration received by ponds which being the catalyst to eutrophication is highly recommended.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

SIK, and NSMK designed and performed the experiments and also wrote the manuscript. NSMK, IH, MGH, HMJ and performed water quality analysis, data collection and analysis. AA and ML reviewed the manuscript. All authors read and approved the final version.

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